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Sap flow prediction model in cocoa trees under different agroforestry arrangements in western Colombian Amazonia

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Background
In the current context of adaptation to and mitigation of climate change, water use in agriculture is a critical issue. Specifically in relation to water use, agroforest systems are considered as a sustainable strategy, as the presence of shade trees above crops induces adequate microclimatic conditions that result in an improved water use status. Indeed the presence of shade trees reduces soil evaporation through a reduction in radiation, wind speed, temperature and an increase in air humidity. Therefore, understand and predict water use in agroforest systems is of a key importance when assessing the environmental impacts of agroforestry practices nowadays.
Aim
The aim of this study is to quantify, compare and model sap flow of cacao trees growing under different shade intensities and its relationship with the microclimatic characteristics generated by these shade intensities. The work is applied to cacao agroforests in the Colombian Amazonia, giving the importance of cacao cropping systems in the world in general, and especially in Colombia within its post conflict context.
Material and Methods
For that purpose, we measured sap flow in three plots with different shade intensities in agroforest systems in the Colombian Amazonia, at the Macagual Center of Investigation – University of Amazonia. We used Sap Flow Meter sensors set up in three random cacao trees in each plot. The sap flow measures was recorded during two weeks within the dry season, with a data recording system that stored a measure every 10 minutes. Shade trees composition and structure were characterized in each plot, along with environmental variables related to sap flow variation, mainly: radiation, humidity, temperature, and vapor pressure deficit.
We then built a mixed linear model that predicted sap flow as a function of the climatic variables measured, and we assessed its predictions compared to the measured values of sap flow using the best (AIC/BIC) models for sap flow and a validation dataset.
Major results and Conclusions
The statistical model we built was able to simulate sap flow variations in each plot during the day, but also sap flow variation between the plots. We simulated real situations of hydrological behavior specific to the cultivation of cocoa under different agroforestry arrangements. Particularly, it predicted the hydraulic redistribution of cacao trees in agroforestry arrangements, as well as nocturnal transpiration in monocultures under the environmental conditions, that we put in evidence for the first time in the region of the Colombian Amazonia. In this sense, hydraulic redistribution may play a fundamental role in the water balance of the cacao plant. This model could be an useful tool for managing and predicting cacao tree water use as a function of the microclimatic conditions in the different agroforest systems in the Colombian Amazonia.